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(54) **MEDICAL IMAGE PROCESSING DEVICE AND MEDICAL IMAGE PROCESSING METHOD**

MEDIZINISCHE BILDVERARBEITUNGSVORRICHTUNG UND MEDIZINISCHES
BILDVERARBEITUNGSVERFAHREN

DISPOSITIF ET PROCEDE DE TRAITEMENT D'IMAGES MEDICALES

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Description

Technical Field

[0001] The present invention relates to a medical image processing apparatus and a medical image processing method, and more particularly to a medical image processing apparatus and a medical image processing method which can detect a protruding shape in a three-dimensional model of a living tissue within a body cavity.

Background Art

[0002] An endoscope system configured by including an endoscope, a medical image processing apparatus and the like is widely used in a medical field or the like. Specifically, the endoscope system is configured by including, for example, the endoscope configured with an insertion portion which is inserted into a body cavity as a living body, an objective optical system placed at a distal end portion of the insertion portion, and an image pickup portion which picks up an image of inside of the body cavity which has been imaged by the objective optical system and outputs the image as an image pickup signal, and the medical image processing apparatus which performs a process for image-displaying the image of the inside of the body cavity on a monitor or the like as a displaying portion, based on the image pickup signal. Then, based on the image of the inside of the body cavity image-displayed on the monitor or the like as the displaying portion, a user performs observation of, for example, an organ or the like as a subject within the body cavity.

[0003] Moreover, the endoscope system including the above described configuration can also pick up an image of a mucosa of the gut such as a large intestine, for example, as the subject within the body cavity. Thus, the user can comprehensively perform various observations of a color tone of the mucosa, a shape of a lesion, a microstructure of a mucous surface, for example.

[0004] Furthermore, in recent years, it is possible to generate a three-dimensional model of the subject based on two-dimensional image data depending on the image pickup signal of the image of the subject picked up by the endoscope. For example, an endoscope apparatus as described in Japanese Patent Application Laid-Open Publication No. 11-337845 has been proposed.

[0005] On the other hand, as a method of detecting a lesion area such as a polyp in the three-dimensional model, for example, a method described in US Patent Application Publication No. 2003/0223627 has been proposed in which the lesion area in the three-dimensional model can be detected by performing evaluation of a shape of the three-dimensional model while using shape feature values based on curvatures such as ShapeIndex and Curvedness.

[0006] Particularly, a two-dimensional image including an image of a living tissue such as large intestinal plicae or the polyp, for example, as an image of a living tissue

having a protruding shape picked up by the endoscope, may often include an invisible region with respect to a viewing direction of the endoscope. Then, the invisible region in the above described two-dimensional image is generally referred to as "occlusion", which is a region where it is difficult to accurately estimate the three-dimensional model. Thus, in a portion in which the occlusion has been generated in the two-dimensional image, for example, no estimation result may exist at a corresponding position in the three-dimensional model based on the two-dimensional image, or an estimation result with low reliability may be calculated at the corresponding position in the three-dimensional model based on the two-dimensional image.

[0007] As a result, if the observation of the subject is performed, while the three-dimensional model of the subject which has been estimated by, for example, image processing performed in the endoscope apparatus of Japanese Patent Application Laid-Open Publication No. 11-337845 as conventional image processing is used, a problem of an increased burden on the user to find the lesion area such as a polyp occurs.

[0008] Moreover, the method of detecting the lesion area such as a polyp, which has been proposed in US Patent Application Publication No. 2003/0223627, is, for example, a method assumed to be applied to a three-dimensional model obtained by observation using CT (Computed Tomography), in which a portion which becomes the occlusion is not generated. Thus, if the method of detecting the lesion area such as a polyp, which has been proposed in US Patent Application Publication No. 2003/0223627, is applied to, for example, a three-dimensional model obtained by observation using the endoscope, which has been estimated based on a two-dimensional image having the portion which becomes the occlusion, accuracy of detecting the lesion area such as a polyp is reduced. As a result, if the observation of the subject is performed while an endoscope system in which the method proposed in US Patent Application Publication No. 2003/0223627 has been employed is used, the problem of the increased burden on the user to find the lesion area such as a polyp occurs.

[0009] KRISHNAN S M ET AL: "Intestinal abnormality detection from endoscopic images", PROCEEDINGS OF THE 20TH ANNUAL INTERNATIONAL CONFERENCE OF THE IEEE, IEEE - PISCATAWAY, NJ, US, vol. 2, 29 October 1998, pages 895-898, XP010320629 discloses a method for detecting the possible presence of abnormality during the endoscopy of the lower gastrointestinal system. Image contours corresponding to haustra creases in the colon are extracted and curvature of each contour is computed after non-parametric smoothing. Zero-crossings of curvature along the contour are then detected. The presence of abnormality is identified when there is a contour segment between two zero-crossings having the opposite curvature signs to those of the two neighboring contour segments.

[0010] TJOA MARTA P ET AL: "Feature extraction for

the analysis of colon status from the endoscopic images", BIOMEDICAL ENGINEERING ONLINE, BIOMED CENTRAL LTD, LONDON, GB, vol. 2, no. 1, 8 April 2003, page 9, XP021018034 discloses methods for extracting texture-and color-based features from the colonoscopic images to classify the colon status and an approach using Principal Component Analysis (PCA) in conjunction with Backpropagation Neural Network (BPNN) for evaluating the features.

[0011] P. S. Hiremath ET AL: "Abnormality Detection in Endoscopic Images Using Color Segmentation and Curvature Computation" in: "Field Programmable Logic and Application", 1 January 2004, Springer Berlin Heidelberg, Berlin, Heidelberg, XP055055171 discloses a method for detecting possible presence of abnormality in the endoscopic images of lower esophagus. The pre-processed endoscopic color images are segmented using color segmentation based on 36-intervals around mean RGB values. The zero-crossing method of edge detection is applied on the gray scale image corresponding to the segmented image.

[0012] The present invention has been made in view of the above described points, and it is an object of the present invention to provide a medical image processing apparatus and a medical image processing method which can prevent a user from overlooking a lesion area such as a polyp in the case where observation is performed by using a three-dimensional model estimated based on a two-dimensional image having occlusion, and thereby can reduce a burden on the user.

Disclosure of Invention

Means for Solving the Problem

[0013] A medical image processing apparatus according to claim 1, and a medical image processing method according to claim 9.

Brief Description of the Drawings

[0014]

Fig. 1 is a diagram showing an example of an overall configuration of an endoscope system in which a medical image processing apparatus according to an embodiment of the present invention is used;

Fig. 2 is a schematic diagram showing a state in the case where the endoscope of Fig. 1 has been inserted into a tubular organ;

Fig. 3 is a schematic diagram showing an image of the tubular organ and a living tissue picked up by the endoscope in the state of Fig. 2;

Fig. 4 is a flowchart showing a procedure of a process performed by the medical image processing apparatus of Fig. 1 in the case where an edge portion in a two-dimensional image of the image of the living tissue is extracted in a first embodiment;

Fig. 5 is a flowchart showing a procedure of a process performed by the medical image processing apparatus of Fig. 1 in the case where a surface portion in the two-dimensional image of the image of the living tissue is extracted in the first embodiment;

Fig. 6 is a flowchart showing a procedure of a process performed by the medical image processing apparatus of Fig. 1 in the case where a protruding shape in a three-dimensional model of the living tissue is detected in the first embodiment;

Fig. 7 is a diagram showing an example of the three-dimensional model of the living tissue estimated by the medical image processing apparatus of Fig. 1;

Fig. 8 is a diagram of the three-dimensional model of the living tissue of Fig. 7 in the case of being seen from another direction;

Fig. 9 is a diagram showing a boundary approximation plane in the three-dimensional model of the living tissue of Figs. 7 and 8;

Fig. 10 is a diagram showing an example in the case where a mirror image based on the boundary approximation plane shown in Fig. 9 has been added in the three-dimensional model of the living tissue of Figs. 7 and 8;

Fig. 11 is a diagram showing an example of a summary of the process performed by the medical image processing apparatus of Fig. 1 in the case where the protruding shape in the three-dimensional model of the living tissue is detected in a second embodiment;

Fig. 12 is a diagram showing an example, which is different from Fig. 11, of the summary of the process performed by the medical image processing apparatus of Fig. 1 in the case where the protruding shape in the three-dimensional model of the living tissue is detected in the second embodiment;

Fig. 13 is a diagram showing an example, which is different from Figs. 7 and 8, of the three-dimensional model of the living tissue estimated by the medical image processing apparatus of Fig. 1;

Fig. 14 is a flowchart showing the procedure of the process performed by the medical image processing apparatus of Fig. 1 in the case where the protruding shape in the three-dimensional model of the living tissue is detected in the third embodiment; and

Fig. 15 is a diagram showing an example of a positional relationship between average coordinates A of a voxel group estimated as a convex shape and average coordinates B of a voxel group estimated as a roof shape, in the three-dimensional model of the living tissue of Fig. 13.

Best Mode for Carrying Out the Invention

[0015] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

(First Embodiment)

[0016] Figs. 1 to 10 relate to a first embodiment of the present invention. Fig. 1 is a diagram showing an example of an overall configuration of an endoscope system in which a medical image processing apparatus according to the present embodiment is used. Fig. 2 is a schematic diagram showing a state in the case where the endoscope of Fig. 1 has been inserted into a tubular organ. Fig. 3 is a schematic diagram showing an image of the tubular organ and a living tissue picked up by the endoscope in the state of Fig. 2. Fig. 4 is a flowchart showing a procedure of a process performed by the medical image processing apparatus of Fig. 1 in the case where an edge portion in a two-dimensional image of the image of the living tissue is extracted in the first embodiment. Fig. 5 is a flowchart showing a procedure of a process performed by the medical image processing apparatus of Fig. 1 in the case where a surface portion in the two-dimensional image of the image of the living tissue is extracted in the first embodiment. Fig. 6 is a flowchart showing a procedure of a process performed by the medical image processing apparatus of Fig. 1 in the case where a protruding shape in a three-dimensional model of the living tissue is detected in the first embodiment. Fig. 7 is a diagram showing an example of the three-dimensional model of the living tissue estimated by the medical image processing apparatus of Fig. 1. Fig. 8 is a diagram of the three-dimensional model of the living tissue of Fig. 7 in the case of being seen from another direction. Fig. 9 is a diagram showing a boundary approximation plane in the three-dimensional model of the living tissue of Figs. 7 and 8. Fig. 10 is a diagram showing an example in the case where a mirror image based on the boundary approximation plane shown in Fig. 9 has been added in the three-dimensional model of the living tissue of Figs. 7 and 8.

[0017] As shown in Fig. 1, a substantial part of an endoscope system 1 is configured with a medical observing apparatus 2 which picks up a subject and also outputs a two-dimensional image of an image of the subject, a medical image processing apparatus 3 which is configured with a personal computer or the like and performs image processing for a video signal of the two-dimensional image outputted from the medical observing apparatus 2 and also outputs the video signal for which the image processing has been performed, as an image signal, and a monitor 4 which displays an image based on the image signal outputted from the medical image processing apparatus 3.

[0018] Moreover, a substantial part of the medical observing apparatus 2 is configured with an endoscope 6 which is inserted into a body cavity and also picks up a subject within the body cavity and outputs the subject as an image pickup signal, a light source apparatus 7 which supplies illumination light for illuminating the subject to be picked up by the endoscope 6, a camera control unit (hereinafter abbreviated as "CCU") 8 which performs var-

ious controls for the endoscope 6, also performs signal processing for the image pickup signal outputted from the endoscope 6, and outputs the image pickup signal as the video signal of the two-dimensional image, and a monitor 9 which image-displays the image of the subject picked up by the endoscope 6, based on the video signal of the two-dimensional image outputted from the CCU 8.

[0019] The endoscope 6 is configured with an insertion portion 11 which is inserted into the body cavity and an operation portion 12 provided on a proximal end side of the insertion portion 11. Moreover, a light guide 13 for transmitting the illumination light supplied by the light source apparatus 7 is inserted through a portion from the proximal end side within the insertion portion 11 to a distal end portion 14 on a distal end side within the insertion portion 11.

[0020] A distal end side of the light guide 13 is placed at the distal end portion 14 of the endoscope 6, and also a rear end side of the light guide 13 is connected to the light source apparatus 7. Since the light guide 13 has such a configuration, the illumination light supplied by the light source apparatus 7 is transmitted by the light guide 13 and subsequently outputted from an illumination window (not shown) provided on a distal end surface at the distal end portion 14 of the insertion portion 11. Then, since the illumination light is outputted from the illumination window (not shown), a living tissue or the like as the subject is illuminated.

[0021] At the distal end portion 14 of the endoscope 6 are provided an objective optical system 15 attached to an observation window (not shown) adjacent to the illumination window (not shown), and an image pickup portion 17 which is placed at an imaging position of the objective optical system 15 and has an image pickup device 16 configured with, for example, a CCD (charge-coupled device) and the like. With such a configuration, the image of the subject imaged by the objective optical system 15 is picked up by the image pickup device 16 and subsequently outputted as the image pickup signal.

[0022] The image pickup device 16 is connected to the CCU 8 via a signal line. Then, the image pickup device 16 is driven based on a driving signal outputted from the CCU 8, and also outputs the image pickup signal depending on the image of the picked-up subject, to the CCU 8.

[0023] Moreover, the image pickup signal inputted to the CCU 8 is applied with the signal processing in a signal processing circuit (not shown) provided within the CCU 8, and thereby converted and outputted as the video signal of the two-dimensional image. The video signal of the two-dimensional image outputted from the CCU 8 is outputted to the monitor 9 and the medical image processing apparatus 3. Thereby, on the monitor 9, the image of the subject based on the video signal outputted from the CCU 8 is displayed as the two-dimensional image.

[0024] The medical image processing apparatus 3 has an image inputting section 21 which performs A/D conversion for the video signal of the two-dimensional image

outputted from the medical observing apparatus 2 and outputs the video signal, a CPU 22 as a central processing unit which performs the image processing for the video signal outputted from the image inputting section 21, a processing program storing section 23 in which a processing program related to the image processing has been written, an image storing section 24 which stores the video signal outputted from the image inputting section 21 and the like, and an information storing section 25 which stores calculation results in the image processing performed by the CPU 22.

[0025] Moreover, the medical image processing apparatus 3 has a storage apparatus interface 26, a hard disk 27 as a storage apparatus which stores image data as a result of the image processing in the CPU 22 via the storage apparatus interface 26, a display processing section 28 which performs display processing for image-displaying the image data on the monitor 4 based on the image data as the image processing result in the CPU 22, and also outputs the image data for which the display processing has been performed, as the image signal, and an input operation section 29 configured with a keyboard and the like with which a user can input parameters in the image processing performed by the CPU 22 and operation instructions to the medical image processing apparatus 3. The monitor 4 displays the image based on the image signal outputted from the display processing section 28.

[0026] It should be noted that the image inputting section 21, the CPU 22, the processing program storing section 23, the image storing section 24, the information storing section 25, the storage apparatus interface 26, the display processing section 28 and the input operation section 29 in the medical image processing apparatus 3 are connected with one another via a data bus 30.

[0027] Next, an operation of the endoscope system 1 will be described.

[0028] First, as shown in Fig. 2, the user inserts the insertion portion 11 of the endoscope 6 into a tubular organ 31 such as a large intestine, for example. Then, when the insertion portion 11 is inserted into the tubular organ 31 by the user, an image of a living tissue 31A which is a lesion area existing on an inner wall of the tubular organ 31, for example, is picked up as an image as shown in Fig. 3 by the image pickup portion 17 provided at the distal end portion 14. Then, the image of the tubular organ 31 and the living tissue 31A picked up as the image as shown in Fig. 3 by the image pickup portion 17 is outputted as the image pickup signal to the CCU 8.

[0029] The CCU 8 performs the signal processing for the image pickup signal outputted from the image pickup device 16 of the image pickup portion 17, in the signal processing circuit (not shown), and thereby converts the image pickup signal into the video signal of the two-dimensional image and outputs the video signal. Then, the monitor 9 displays the image of the tubular organ 31 and the living tissue 31A based on the video signal outputted from the CCU 8, as the two-dimensional image as shown

in Fig. 3, for example. Moreover, the CCU 8 outputs the video signal of the two-dimensional image obtained by performing the signal processing for the image pickup signal outputted from the image pickup device 16 of the image pickup portion 17, to the medical image processing apparatus 3.

[0030] The video signal of the two-dimensional image outputted to the medical image processing apparatus 3 is A/D converted in the image inputting section 21, and subsequently inputted to the CPU 22.

[0031] Based on the video signal of the two-dimensional image outputted from the image inputting section 21 and the processing program written in the processing program storing section 23, the CPU 22 extracts an edge portion of the living tissue 31A in the two-dimensional image, by performing a process as described below, for example.

[0032] First, based on the video signal of the two-dimensional image outputted from the image inputting section 21, the CPU 22 extracts all edge portions included in the two-dimensional image, by applying a band-pass filter for red components of the two-dimensional image, for example (step S1 of Fig. 4).

[0033] Subsequently, the CPU 22 having a function as a region detecting section applies thinning to all the extracted edge portions (step S2 of Fig. 4), and also calculates a length L of one edge portion E among all the edge portions applied with the thinning (step S3 of Fig. 4). Furthermore, the CPU 22 determines whether or not the length L of the one edge portion E is longer than a threshold thL1 and shorter than a threshold thL2.

[0034] Then, if the CPU 22 has detected that the length L of the one edge portion E is a length equal to or shorter than the predetermined threshold thL1, or a length equal to or longer than the threshold thL2 (step S4 of Fig. 4), the CPU 22 performs a process shown at step S11 of Fig. 4 as described below. Moreover, if the CPU 22 has detected that the length L of the one edge portion E is longer than the threshold thL1 and shorter than the threshold thL2 (step S4 of Fig. 4), the CPU 22 equally divides the one edge portion E into N at control points Cn (n=1, 2, ..., N) (step S5 of Fig. 4).

[0035] Furthermore, the CPU 22 obtains a normal line NCc drawn from a midpoint Cc of the one edge portion E, and also obtains N normal lines NCn drawn from the respective control points Cn (step S6 of Fig. 4). Subsequently, the CPU 22 detects the number of normal lines Na which intersect with the normal line NCc among the N normal lines NCn (step S7 of Fig. 4).

[0036] Moreover, the CPU 22 determines whether or not the number of normal lines Na which intersect with the normal line NCc among the N normal lines NCn is larger than a threshold tha. Then, if the CPU 22 having the function as the region detecting section has detected that the number of normal lines Na which intersect with the normal line NCc is larger than the threshold tha (step S8 of Fig. 4), the CPU 22 determines that a pixel group ip included in the one edge portion E is a pixel group

included in the edge portion of the living tissue 31A, and sets a value of a variable edge(i) in each pixel included in the pixel group ip to ON (step S9 of Fig. 4). Furthermore, then, if the CPU 22 has detected that the number of normal lines Na which intersect with the normal line NCc is equal to or smaller than the threshold tha (step S8 of Fig. 4), the CPU 22 determines that the pixel group ip included in the one edge portion E is not the pixel group included in the edge portion of the living tissue 31A, and sets the value of the variable edge(i) in each pixel included in the pixel group ip to OFF (step S10 of Fig. 4).

[0037] In other words, the CPU 22 having the function as the region detecting section determines that a visible region and an invisible region in the two-dimensional image are separated by a boundary which is the pixel group with the value of the variable edge(i) of ON, by performing the above described process.

[0038] The CPU 22 determines whether or not the process has been completed for all the extracted edge portions. Then, if the CPU 22 has detected that the process has not been completed for all the extracted edge portions (step S11 of Fig. 4), the CPU 22 performs the above described process from step S3 of Fig. 4 to step S10 of Fig. 4 for another one edge portion. Moreover, if the CPU 22 has detected that the process has been completed for all the extracted edge portions (step S11 of Fig. 4), the CPU 22 completes a series of processes for extracting the edge portion of the living tissue 31A in the two-dimensional image.

[0039] Subsequently, the CPU 22 temporarily stores the value of the variable edge(i) in the pixel group ip included in each edge portion of the two-dimensional image, in the information storing section 25, as a processing result obtained by performing the series of processes for extracting the edge portion of the living tissue 31A in the two-dimensional image, as described above.

[0040] Based on the value of the variable edge(i) stored in the information storing section 25 and the processing program written in the processing program storing section 23, the CPU 22 extracts a surface portion of the living tissue 31A in the two-dimensional image by performing the above described process shown in Fig. 4, for example, and subsequently further performing a process as described below.

[0041] First, the CPU 22 obtains a thin line of the one edge portion E with the variable edge(i) of ON, based on the value of the variable edge(i) stored in the information storing section 25 (step S21 of Fig. 5). Subsequently, the CPU 22 obtains points at both ends of the thin line of the one edge portion E with the variable edge(i) of ON (step S22 of Fig. 5).

[0042] Then, the CPU 22 regards a pixel group jp surrounded by the thin line of the one edge portion E with the variable edge(i) of ON and a line connecting the points at the both ends of the thin line obtained at step S22 of Fig. 5 as described above, as the visible region in the two-dimensional image of the living tissue 31 A, that is, as a pixel group included in the surface portion of the

living tissue 31 A, and sets a variable omote(j) in each pixel included in the pixel group jp to ON (step S23 of Fig. 5).

[0043] The CPU 22 determines whether or not the process has been completed for all the edge portions with the variable edge(i) of ON. Then, if the CPU 22 has detected that the process has not been completed for all the edge portions with the variable edge(i) of ON (step S24 of Fig. 5), the CPU 22 performs the above described process from step S21 of Fig. 5 to step S23 of Fig. 5 for another one edge portion. Moreover, if the CPU 22 has detected that the process has been completed for all the edge portions with the variable edge (i) of ON (step S24 of Fig. 5), the CPU 22 completes a series of processes for extracting the surface portion of the living tissue 31A in the two-dimensional image.

[0044] Subsequently, the CPU 22 temporarily stores the value of the variable omote(j) in the pixel group jp included in each surface portion of the two-dimensional image, in the information storing section 25, as a processing result obtained by performing the series of processes for extracting the surface portion of the living tissue 31A in the two-dimensional image, as described above.

[0045] Then, the CPU 22 having a function as a three-dimensional model estimating section performs image processing for obtaining image data required for estimating a three-dimensional model of the tubular organ 31 and the living tissue 31 A based on luminance information in the video signal of the two-dimensional image outputted from the image inputting section 21, by a process such as geometric conversion. In other words, the CPU 22 generates a voxel corresponding to each pixel in the two-dimensional image and also obtains the voxel as the image data for estimating the three-dimensional model, by the process such as the geometric conversion. That is to say, the pixel group ip and the pixel group jp are converted as a voxel group ib and a voxel group jb by the above described process.

[0046] The CPU 22 obtains data on a living tissue surface portion 31a which is a plane including the voxel group jb with the variable omote(j) of ON, and data on a living tissue boundary portion 31b which is a plane including the voxel group ib with the variable edge(i) of ON, as the image data for estimating the three-dimensional model of the living tissue 31A shown in Fig. 3, by the above described process. Thereby, if a z-axis direction is a viewing direction during observation with the endoscope 6, for example, the living tissue 31 A is estimated as the three-dimensional model having a shape as shown in Fig. 7.

[0047] Incidentally, the living tissue 31A estimated as the three-dimensional model having the shape as shown in Fig. 7 by performing the above described process has an invisible region 31c in a region, for example, as shown in Fig. 8, in the case of being seen from an x-axis direction. Based on the data on the living tissue surface portion 31a and the data on the living tissue boundary portion 31 b, the CPU 22 further estimates a three-dimensional

model of the invisible region 31 c of the living tissue 31A and also detects a protruding shape in the estimated three-dimensional model of the living tissue 31A, by performing a process as described below.

[0048] First, based on the processing program written in the processing program storing section 23 and the data on the living tissue boundary portion 31b, the CPU 22 calculates an approximation plane 31d which is a plane including the largest number of respective voxels included in the voxel group ib of the living tissue boundary portion 31b and is a plane, for example, as shown in Fig. 9 (step S31 of Fig. 6).

[0049] Next, based on the data on the living tissue surface portion 31a, the CPU 22 adds new voxels at predetermined positions in the invisible region 31c. Specifically, based on the data on the living tissue surface portion 31a, the CPU 22 adds the new voxels at positions which are symmetric with respect to the approximation plane 31d from respective voxels included in the living tissue surface portion 31a, as the predetermined positions (step S32 of Fig. 6). By performing the above described process by the CPU 22, the living tissue 31A is estimated as a three-dimensional model having the living tissue surface portion 31a and a living tissue rear surface portion 31e generated as a mirror image of the living tissue surface portion 31a, for example, as shown in Fig. 10. That is to say, the above described three-dimensional model of the invisible region 31c of the living tissue 31A is estimated as the living tissue rear surface portion 31e.

[0050] Subsequently, the CPU 22 further performs a process as described below for respective P voxels which are all the voxels obtained as the image data for estimating the three-dimensional model of the tubular organ 31 and the living tissue 31A.

[0051] After setting a variable i to 1 (step S33 of Fig. 6), the CPU 22 having a function as a shape feature value calculating section extracts Bi (i=1, 2, ..., P-1, P) which is one voxel of the P voxels (step S34 of Fig. 6), and also calculates a ShapeIndex value SBi and a Curvedness value CBi as shape feature values in the one voxel Bi (step S35 of Fig. 6).

[0052] It should be noted that the above described ShapeIndex value and Curvedness value can be calculated, by using a method similar to the method described in US Patent Application Publication No. 2003/0223627, for example. Thus, in the present embodiment, a description of a method of calculating the ShapeIndex value and the Curvedness value in the one voxel Bi is omitted.

[0053] Furthermore, the CPU 22 having a function as a three-dimensional shape extracting section performs comparison between the ShapeIndex value SBi and a preset threshold of the ShapeIndex value, Sth, and also performs comparison between the Curvedness value CBi and a preset threshold of the Curvedness value, Cth. In other words, by performing the above described process, the CPU 22 performs a process of extracting a voxel group whose three-dimensional model has been estimated as a convex shape, as a process for detecting whether

or not the living tissue 31A is the protruding shape. It should be noted that, in a series of processes shown in Fig. 6, in order to detect the living tissue 31A having the convex shape as the protruding shape, it is assumed that the threshold Sth has been set to 0.9 and the threshold Cth has been set to 0.2, for example.

[0054] Then, if the CPU 22 having a function as a protruding shape detecting section has detected that the ShapeIndex value SBi is larger than the threshold Sth and the Curvedness value CBi is larger than the threshold Cth (step S36 of Fig. 6), the CPU 22 determines that the one voxel Bi is a voxel configuring a part of the protruding shape, and sets a value of a variable ryuuki(Bi) in the one voxel Bi to ON (step S37 of Fig. 6).

[0055] Moreover, if the CPU 22 has detected that the ShapeIndex value SBi is equal to or smaller than the threshold Sth, or the Curvedness value CBi is equal to or smaller than the threshold Cth (step S36 of Fig. 6), the CPU 22 determines that the one voxel Bi is not the voxel configuring a part of the protruding shape, and sets the value of the variable ryuuki(Bi) in the one voxel Bi to OFF (step S38 of Fig. 6).

[0056] Subsequently, the CPU 22 determines whether or not the above described process has been performed for all the P voxels, that is, whether or not the variable i=P.

[0057] Then, if the CPU 22 has sensed that i is not P (step S39 of Fig. 6), the CPU 22 performs a process of adding 1 to the variable i (step S40 of Fig. 6) and subsequently performs the above described process shown from step S34 to step S39 of Fig. 6 again.

[0058] And, if the CPU 22 has sensed that i=P (step S39 of Fig. 6), the CPU 22 completes a series of processes for detecting the protruding shape in the three-dimensional model of the living tissue 31A.

[0059] Then, for the display processing section 28, the CPU 22 performs a control such as superimposing a character string, coloring or the like for indicating that the living tissue 31A is the protruding shape upon the three-dimensional model, for example, in the three-dimensional model having the voxel with the value of ryuuki(Bi) of ON. Thereby, on the monitor 4, the three-dimensional model of the tubular organ 31 and the living tissue 31A is image-displayed so that the user can easily find the living tissue 31A having the protruding shape.

[0060] Moreover, based on a position of each voxel with the value of ryuuki(Bi) of ON, the CPU 22 may detect each pixel on the two-dimensional image existing at a position corresponding to the position of the each voxel, and also may perform a control such as superimposing the character string, the coloring or the like for indicating that the living tissue 31A is the protruding shape upon the two-dimensional image having the each pixel, for the display processing section 28.

[0061] The medical image processing apparatus 3 of the present embodiment can prevent the user from overlooking the lesion area such as a polyp, by performing a series of processes as described above, and thereby can reduce a burden on the user.

(Second Embodiment)

[0062] Figs. 11 and 12 relate to a second embodiment of the present invention. It should be noted that a detailed description of a portion having a configuration similar to that of the first embodiment is omitted. Moreover, the same reference character is used for a component similar to that of the first embodiment and a description thereof is omitted. Furthermore, the configuration of the endoscope system 1 used in the present embodiment is similar to that of the first embodiment.

[0063] Fig. 11 is a diagram showing an example of a summary of the process performed by the medical image processing apparatus of Fig. 1 in the case where the protruding shape in the three-dimensional model of the living tissue is detected in the second embodiment. Fig. 12 is a diagram showing an example, which is different from Fig. 11, of the summary of the process performed by the medical image processing apparatus of Fig. 1 in the case where the protruding shape in the three-dimensional model of the living tissue is detected in the second embodiment.

[0064] The ShapeIndex value and the Curvedness value as the shape feature values calculated during the series of processes described in an explanation of the first embodiment are values calculated based on two values of a Gaussian curvature and a mean curvature. Thus, the CPU 22 may perform the process by calculating the two values of the Gaussian curvature and the mean curvature as the shape feature values, instead of two values of the ShapeIndex value and the Curvedness value. Then, in that case, the CPU 22 performs a process with contents described below, as a process corresponding to the process shown at step S35 of Fig. 6 described in the first embodiment.

[0065] The CPU 22 having the function as the shape feature value calculating section calculates a local plane equation of a local region including a group of $M \times M \times M$ voxels including a first voxel, for example, as peripheral voxel information which is information on voxels existing in a peripheral region of one voxel. Then, the CPU 22 having the function as the shape feature value calculating section calculates the Gaussian curvature and the mean curvature of the first voxel included in the group of $M \times M \times M$ voxels based on the peripheral voxel information.

[0066] Specifically, as shown in Fig. 11, the CPU 22 calculates the local plane equation of the local region including a group of $5 \times 5 \times 5$ voxels including a desired first voxel, for example, as the peripheral voxel information, and also calculates the Gaussian curvature and the mean curvature of the desired first voxel based on the peripheral voxel information.

[0067] Moreover, if the CPU 22 having the function as the shape feature value calculating section has sensed that at least one voxel in the respective voxels included in the voxel group ib with the variable edge(i) of ON is included within the local region, the CPU 22 further cal-

culates the local plane equation of the local region including a group of $K \times K \times K$ voxels ($K < M$) including a second voxel, for example, as the peripheral voxel information. Then, the CPU 22 having the function as the shape feature value calculating section calculates the Gaussian curvature and the mean curvature of the second voxel included in the group of $K \times K \times K$ voxels based on the peripheral voxel information.

[0068] Specifically, as shown in Fig. 12, the CPU 22 calculates the local plane equation of the local region including a group of $3 \times 3 \times 3$ voxels including a desired second voxel, for example, as the peripheral voxel information, and also calculates the Gaussian curvature and the mean curvature of the desired second voxel based on the peripheral voxel information.

[0069] The CPU 22 can extract more voxels configuring a part of the protruding shape by performing the above described process. As a result, the medical image processing apparatus 3 of the present embodiment can prevent the user from overlooking the lesion area such as a polyp, and thereby can reduce the burden on the user and also improve accuracy of detecting the lesion area.

[0070] It should be noted that, in the above described process for the three-dimensional model of the living tissue 31A, the CPU 22 may perform a process of calculating only the shape feature values of proximity of the living tissue surface portion 31 a and the living tissue boundary portion 31 b which are the visible region in which an estimation result has relatively high reliability, without calculating the shape feature values of the invisible region 31c in which the estimation result has relatively low reliability. In that case, the medical image processing apparatus 3 of the present embodiment can detect the lesion area such as a polyp with higher accuracy.

(Third Embodiment)

[0071] Figs. 13, 14 and 15 relate to a third embodiment of the present invention. It should be noted that a detailed description of a portion having a configuration similar to that of the first embodiment is omitted. Moreover, the same reference character is used for a component similar to that of the first embodiment and a description thereof is omitted. Furthermore, the configuration of the endoscope system 1 used in the present embodiment is similar to that of the first embodiment.

[0072] Fig. 13 is a diagram showing an example, which is different from Figs. 7 and 8, of the three-dimensional model of the living tissue estimated by the medical image processing apparatus of Fig. 1. Fig. 14 is a flowchart showing the procedure of the process performed by the medical image processing apparatus of Fig. 1 in the case where the protruding shape in the three-dimensional model of the living tissue is detected in the third embodiment. Fig. 15 is a diagram showing an example of a positional relationship between average coordinates A

of the voxel group estimated as the convex shape and average coordinates B of a voxel group estimated as a roof shape, in the three-dimensional model of the living tissue of Fig. 13.

[0073] In the series of processes described in the explanation of the first embodiment, the CPU 22 may calculate the shape feature values of respective voxels virtually existing at the positions which are symmetric with respect to the approximation plane 31d from the respective voxels included in the living tissue surface portion 31a, for example, and also determine whether or not the protruding shape exists at the positions, based on the calculated shape feature values, without performing the process for estimating the living tissue rear surface portion 31e as the three-dimensional model of the invisible region 31c of the living tissue 31A (the process shown at step S32 of Fig. 6).

[0074] Incidentally, when the CPU 22 estimates the three-dimensional model from the two-dimensional image of the living tissue 31A, as described in the explanation of the first embodiment, the process based on the luminance information, for example, is performed. Thus, in the case where a boundary portion (edge portion) between the visible region and the invisible region in the two-dimensional image of the living tissue 31A has the luminance information which is darker than normal, the living tissue 31A can be estimated as the three-dimensional model of a shape, for example, as shown in Fig. 13, which has a roof shape in the invisible region existing in the z-axis direction as the viewing direction during the observation with the endoscope 6 (or a luminal central direction), even if an actual shape thereof is the convex shape.

[0075] In such a case, performing a process described below by the CPU 22 detects whether or not the living tissue 31A estimated as the three-dimensional model is the protruding shape.

[0076] First, after setting a variable j to 1 (step S41 of Fig. 14), the CPU 22 extracts Bj (j=1, 2, ..., Q-1, Q) which is one voxel of Q voxels included in one curved plane in the three-dimensional model (step S42 of Fig. 14), and also calculates a ShapexIndex value SBj and a Curvedness value CBj as shape feature values in the one voxel Bj (step S43 of Fig. 14).

[0077] Furthermore, the CPU 22 performs comparison between the ShapexIndex value SBj and a preset threshold of the ShapexIndex value, Sth1, and also performs comparison between the Curvedness value CBj and a preset threshold of the Curvedness value, Cth1. In other words, by performing the above described process, the CPU 22 performs the process of extracting the voxel group whose three-dimensional model has been estimated as the convex shape, as the process for detecting whether or not the living tissue 31A is the protruding shape. It should be noted that, in a series of processes shown in Fig. 14, in order to detect the living tissue 31A having the convex shape as the protruding shape, it is assumed that the threshold Sth1 has been set to 0.9 and

the threshold Cth1 has been set to 0.2, for example.

[0078] Then, if the CPU 22 has detected that the ShapexIndex value SBj is larger than the threshold Sth1 and the Curvedness value CBj is larger than the threshold Cth1 (step S44 of Fig. 14), the CPU 22 determines that the one voxel Bj is a candidate for the voxel configuring a part of the protruding shape, and sets a value of a variable ryuuki1 (Bj) in the one voxel Bj to ON (step S45 of Fig. 14).

[0079] Moreover, if the CPU 22 has detected that the ShapexIndex value SBj is equal to or smaller than the threshold Sth1, or the Curvedness value CBj is equal to or smaller than the threshold Cth1 (step S44 of Fig. 14), the CPU 22 further performs comparison between the ShapexIndex value SBj and a preset threshold of the ShapexIndex value, Sth2. It should be noted that, in the series of processes shown in Fig. 14, in order to detect the living tissue 31A having the roof shape as the protruding shape, it is assumed that the threshold Sth2 has been set to 0.75, for example.

[0080] If the CPU 22 has detected that the ShapexIndex value SBj is larger than the threshold Sth2 (step S46 of Fig. 14), the CPU 22 sets a value of a variable ryuuki2(Bj) in the one voxel Bj to ON (step S47 of Fig. 14).

[0081] Subsequently, the CPU 22 determines whether or not the above described process has been performed for all the Q voxels included in the one curved plane in the three-dimensional model, that is, whether or not the variable j=Q.

[0082] Then, if the CPU 22 has sensed that j is not Q (step S48 of Fig. 14), the CPU 22 performs a process of adding 1 to the variable j (step S49 of Fig. 14) and subsequently performs the above described process shown from step S42 to step S48 of Fig. 14 again.

[0083] Moreover, if the CPU 22 has sensed that j=Q (step S48 of Fig. 14), the CPU 22 calculates a distance L, for example, between average coordinates A (X1, Y1, Z1) of a voxel group with the variable ryuuki1(Bj) of ON and average coordinates B (X2, Y2, Z2) of a voxel group with the variable ryuuki2(Bj) of ON, as shown in Fig. 15 (step S50 of Fig. 14). Subsequently, the CPU 22 determines whether or not the voxel group with the variable ryuuki1(Bj) of ON and the voxel group with the variable ryuuki2(Bj) of ON exist within a predetermined range, by performing comparison between the distance L and a threshold of the distance between A and B, thL.

[0084] If the CPU 22 has sensed that the distance L is equal to or longer than the threshold thL (step S51 of Fig. 14), the CPU 22 determines that the one curved plane having the voxel group with the variable ryuuki1(Bj) of ON and the voxel group with the variable ryuuki2(Bj) of ON is not voxels configuring the protruding shape, performs a process of setting the value of the variable ryuuki1(Bj) or the variable ryuuki2(Bj) in each of the Q voxels to OFF (step S52 of Fig. 14), and subsequently completes a series of processes. Moreover, if the CPU 22 has sensed that the distance L is shorter than the threshold thL (step S51 of Fig. 14), the CPU 22 deter-

mines that the one curved plane having the voxel group with the variable $ryuuki1(Bj)$ of ON and the voxel group with the variable $ryuuki2(Bj)$ of ON is the voxels configuring the protruding shape, and completes the series of processes, leaving the value of the variable $ryuuki1(Bj)$ or the variable $ryuuki2(Bj)$ in each of the Q voxels as ON. Thereby, the CPU 22 can detect a polyp or the like which is the lesion area having the protruding shape, with the higher accuracy. Particularly, in addition to a lesion area protruding as a generally hemispherical shape (a polyp or the like), the CPU 22 can also detect a lesion area protruding with a generally semicylindrical area (the polyp or the like), for example, which is relatively likely to be overlooked by the user, by performing the series of processes of the present embodiment. As a result, the medical image processing apparatus 3 of the present embodiment can prevent the user from overlooking the lesion area such as a polyp, and thereby can reduce the burden on the user.

[0085] It should be noted that the present invention is not limited to the above described respective embodiments, and of course, various modifications and applications are possible within the scope of the appended claims.

Claims

1. A medical image processing apparatus comprising:

a region detecting section configured for detecting, as a boundary portion, an edge portion corresponding to a predetermined condition among all edge portions included in a two-dimensional image obtained by picking up an image of a living tissue in a body cavity, and further detecting, based on the boundary portion, a visible region and an invisible region in the two-dimensional image;

a three-dimensional model estimating section configured for estimating, based on luminance information of the two-dimensional image, a three-dimensional model corresponding to the visible region by performing a geometric conversion process for generating a voxel corresponding to each pixel in the two-dimensional image, and estimating, from voxels included in the visible region, a three-dimensional model corresponding to the invisible region by adding voxels at positions symmetric with respect to the boundary portion, and further estimating a three-dimensional model of the living tissue as having the three-dimensional model corresponding to the visible region and the three-dimensional model corresponding to the invisible region;

a shape feature value calculating section configured for calculating shape feature values of respective voxels included in at least the visible

region of the three-dimensional model of the living tissue;

a three-dimensional shape extracting section configured for extracting a first voxel group whose three-dimensional model has been estimated as a predetermined shape, in the respective voxels included in the three-dimensional model of the living tissue, based on a result of calculation by the shape feature value calculating section; and

a protruding shape detecting section configured for detecting the first voxel group as a voxel group configuring a protruding shape in the three-dimensional model of the living tissue.

2. The medical image processing apparatus according to claim 1, wherein the predetermined shape is a convex shape.

3. The medical image processing apparatus according to claim 1, wherein the three-dimensional shape extracting section further detects a second voxel group which is a voxel group whose three-dimensional model has been estimated as a convex shape and a third voxel group which is a voxel group whose three-dimensional model has been estimated as a roof shape, in voxel groups included in one curved plane in the three-dimensional model of the living tissue, and if the second voxel group and the third voxel group exist within a predetermined range, the three-dimensional shape extracting section extracts the second voxel group and the third voxel group as the first voxel group.

4. The medical image processing apparatus according to claim 1, wherein the three-dimensional shape extracting section further detects a second voxel group which is a voxel group whose three-dimensional model has been estimated as a convex shape and a third voxel group which is a voxel group whose three-dimensional model has been estimated as a roof shape, in voxel groups included in one curved plane in the three-dimensional model of the living tissue, and if the third voxel group existing in the invisible region and the second voxel group existing in the visible region exist within a predetermined range, the three-dimensional shape extracting section extracts the second voxel group and the third voxel group as the first voxel group.

5. The medical image processing apparatus according to claim 3 or 4, wherein the three-dimensional shape extracting section further determines whether or not the third voxel group existing in the invisible region and the second voxel group existing in the visible region exist within the predetermined range, based on a distance between average coordinates of the second voxel group and average coordinates of the

third voxel group.

6. The medical image processing apparatus according to claim 1, wherein the shape feature value calculating section calculates shape feature values at respective voxels included in the visible region and respective voxels included in the invisible region.
7. The medical image processing apparatus according to claim 1, wherein the shape feature value calculating section calculates shape feature values only in respective voxels included in the visible region.
8. The medical image processing apparatus according to claim 1, wherein based on peripheral region voxel information which is information on voxels existing in a peripheral region of one voxel, the shape feature value calculating section calculates the shape feature values of the one voxel, and if the shape feature value calculating section has sensed that a voxel including the boundary portion exists within the peripheral region, the shape feature value calculating section reduces peripheral voxel information used for calculating the shape feature values of the one voxel.
9. A medical image processing method comprising:

a region detecting step of detecting, as a boundary portion, an edge portion corresponding to a predetermined condition among all edge portions included in a two-dimensional image obtained by picking up an image of a living tissue in a body cavity, and further detecting, based on the boundary portion, a visible region and an invisible region in the two-dimensional image; a three-dimensional model estimating step of estimating, based on luminance information of the two-dimensional image, a three-dimensional model corresponding to the visible region by performing a geometric conversion process for generating a voxel corresponding to each pixel in the two-dimensional image, and estimating, from voxels included in the visible region, a three-dimensional model corresponding to the invisible region by adding voxels at positions symmetric with respect to the boundary portion, and further estimating a three-dimensional model of the living tissue as having the three-dimensional model corresponding to the visible region and the three-dimensional model corresponding to the invisible region; a shape feature value calculating step of calculating shape feature values of respective voxels included in at least the visible region of the three-dimensional model of the living tissue; a three-dimensional shape extracting step of extracting a first voxel group whose three-dimensional

model has been estimated as a predetermined shape, in the respective voxels included in the three-dimensional model of the living tissue, based on a result of calculation by the shape feature value calculating step; and a protruding shape detecting step of detecting the first voxel group as a voxel group configuring a protruding shape in the three-dimensional model of the living tissue.

10. The medical image processing method according to claim 9, wherein the predetermined shape is a convex shape.
11. The medical image processing method according to claim 9, wherein the three-dimensional shape extracting step further detects a second voxel group which is a voxel group whose three-dimensional model has been estimated as a convex shape and a third voxel group which is a voxel group whose three-dimensional model has been estimated as a roof shape, in voxel groups included in one curved plane in the three-dimensional model of the living tissue, and if the second voxel group and the third voxel group exist within a predetermined range, the three-dimensional shape extracting step extracts the second voxel group and the third voxel group as the first voxel group.
12. The medical image processing method according to claim 9, wherein the three-dimensional shape extracting step further detects a second voxel group which is a voxel group whose three-dimensional model has been estimated as a convex shape and a third voxel group which is a voxel group whose three-dimensional model has been estimated as a roof shape, in voxel groups included in one curved plane in the three-dimensional model of the living tissue, and if the third voxel group existing in the invisible region and the second voxel group existing in the visible region exist within a predetermined range, the three-dimensional shape extracting step extracts the second voxel group and the third voxel group as the first voxel group.
13. The medical image processing method according to claim 11 or 12, wherein the three-dimensional shape extracting step further determines whether or not the third voxel group existing in the invisible region and the second voxel group existing in the visible region exist within the predetermined range, based on a distance between average coordinates of the second voxel group and average coordinates of the third voxel group.
14. The medical image processing method according to claim 9, wherein the shape feature value calculating step calculates shape feature values at respective

voxels included in the visible region and respective voxels included in the invisible region.

15. The medical image processing method according to claim 9, wherein the shape feature value calculating step calculates shape feature values only in respective voxels included in the visible region. 5
16. The medical image processing method according to claim 9, wherein based on peripheral region voxel information which is information on voxels existing in a peripheral region of one voxel, the shape feature value calculating step calculates the shape feature values of the one voxel, and if the shape feature value calculating step has sensed that a voxel including the boundary portion exists within the peripheral region, the shape feature value calculating step reduces peripheral voxel information used for calculating the shape feature values of the one voxel. 10 15 20

Patentansprüche

1. Medizinische Bildverarbeitungsvorrichtung mit:

einem Region-Ermittlungsbereich, der dazu ausgebildet ist, aus allen Randabschnitten in einem zweidimensionalen Bild, das durch Bildaufnahme eines lebenden Gewebes in einem Körperhohlraum gewonnen wird, einen Randabschnitt gemäß einer vorgegebenen Bedingung als Grenzbereich zu ermitteln und des Weiteren auf der Grundlage des Grenzbereiches eine sichtbare Region und eine unsichtbare Region im zweidimensionalen Bild zu ermitteln; 25 30 35

einem dreidimensionalen Modell-Schätzbereich, der dazu ausgebildet ist, auf der Grundlage von Luminanzinformationen des zweidimensionalen Bildes ein dreidimensionales Modell entsprechend der sichtbaren Region abzuschätzen, indem ein geometrischer Umwandlungsprozess zum Erzeugen eines Voxels entsprechend jedem Pixel in dem zweidimensionalen Bild ausgeführt wird, und aus Voxeln in der sichtbaren Region ein dreidimensionales Modell entsprechend der unsichtbaren Region abzuschätzen, indem Voxel an Positionen hinzugefügt werden, die zum Grenzbereich symmetrisch sind, und des Weiteren ein dreidimensionales Modell des lebenden Gewebes abzuschätzen, als ob das dreidimensionale Modell dem sichtbaren Bereich entspräche und das dreidimensionale Modell dem unsichtbaren Bereich entspräche; 40 45 50 55

einem Formmerkmalswert-Berechnungsbereich, der dazu ausgebildet ist, Formmerkmalswerte jeweiliger Voxel zu berechnen, die zumin-

dest in der sichtbaren Region des dreidimensionalen Modells des lebenden Gewebes enthalten sind;

einem Dreidimensional-Form-Extrahierbereich, der dazu ausgebildet ist, eine erste Voxelgruppe, deren dreidimensionales Modell als eine vorgegebene Form abgeschätzt wurde, in den jeweiligen, in dem dreidimensionalen Modell des lebenden Gewebes enthaltenen Voxeln auf der Grundlage eines Ergebnisses einer Berechnung durch den Formmerkmalswert-Berechnungsbereich zu extrahieren; und einem Vorspringform-Ermittlungsbereich, der dazu ausgebildet ist, die erste Voxelgruppe als eine Voxelgruppe zu ermitteln, die eine Vorspringform in dem dreidimensionalen Modell des lebenden Gewebes ausbildet.

2. Medizinische Bildverarbeitungsvorrichtung nach Anspruch 1, wobei die vorgegebene Form eine konvexe Form ist. 20
3. Medizinische Bildverarbeitungsvorrichtung nach Anspruch 1, wobei der Dreidimensional-Form-Extrahierbereich des Weiteren eine zweite Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine konvexe Form abgeschätzt wurde, und eine dritte Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine Dachform abgeschätzt wurde, in Voxelgruppen ermittelt, die in einer gekrümmten Fläche in dem dreidimensionalen Modell des lebenden Gewebes enthalten sind, und, wenn die zweite Voxelgruppe und die dritte Voxelgruppe innerhalb eines vorgegebenen Bereiches liegen, der Dreidimensional-Form-Extrahierbereich die zweite Voxelgruppe und die dritte Voxelgruppe als die erste Voxelgruppe extrahiert. 25 30 35 40 45 50 55
4. Medizinische Bildverarbeitungsvorrichtung nach Anspruch 1, wobei der Dreidimensional-Form-Extrahierbereich des Weiteren eine zweite Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine konvexe Form abgeschätzt wurde, und eine dritte Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine Dachform abgeschätzt wurde, in Voxelgruppen ermittelt, die in einer gekrümmten Fläche in dem dreidimensionalen Modell des lebenden Gewebes enthalten sind, und, wenn die dritte Voxelgruppe, die sich in der unsichtbaren Region befindet, und die zweite Voxelgruppe, die sich in der sichtbaren Region befindet, innerhalb eines vorgegebenen Bereiches liegen, der Dreidimensional-Form-Extrahierbereich die zweite Voxelgruppe und die dritte Voxelgruppe als die erste Voxelgruppe extrahiert.
5. Medizinisches Bildverarbeitungsverfahren nach Anspruch 3 oder 4, wobei der Dreidimensional-Form-

- Extrahierschritt des Weiteren auf der Grundlage eines Abstandes zwischen Durchschnittskoordinaten der zweiten Voxelgruppe und Durchschnittskoordinaten der dritten Voxelgruppe bestimmt, ob die dritte Voxelgruppe, die sich in der unsichtbaren Region befindet, und die zweite Voxelgruppe, die sich in der sichtbaren Region befindet, innerhalb des vorgegebenen Bereiches liegen oder nicht. 5
6. Medizinische Bildverarbeitungsvorrichtung nach Anspruch 1, wobei der Formmerkmalswert-Berechnungsbereich Formmerkmalswerte bei jeweiligen Voxeln in der sichtbaren Region und bei jeweiligen Voxeln in der unsichtbaren Region berechnet. 10
7. Medizinische Bildverarbeitungsvorrichtung nach Anspruch 1, wobei der Formmerkmalswert-Berechnungsbereich Formmerkmalswerte nur in jeweiligen Voxeln in der sichtbaren Region berechnet. 15
8. Medizinische Bildverarbeitungsvorrichtung nach Anspruch 1, wobei der Formmerkmalswert-Berechnungsbereich auf der Grundlage von Randregion-Voxelinformationen, die Informationen über Voxel sind, die sich in einer Randregion eines Voxels befinden, die Formmerkmalswerte des einen Voxels berechnet und, wenn der Formmerkmalswert-Berechnungsbereich erkannt hat, dass ein Voxel, welches den Grenzbereich umfasst, innerhalb der Randregion liegt, der Formmerkmalswert-Berechnungsbereich Randvoxelinformationen verringert, die zum Berechnen der Formmerkmalswerte des einen Voxels verwendet werden. 20 25 30
9. Medizinisches Bildverarbeitungsverfahren mit: 35
- einem Region-Ermittlungsschritt zum Ermitteln eines Randabschnitts gemäß einer vorgegebenen Bedingung als Grenzbereich aus allen Randabschnitten in einem zweidimensionalen Bild, das durch Bildaufnahme eines lebenden Gewebes in einem Körperhohlraum gewonnen wird, und des Weiteren zum Ermitteln einer sichtbaren Region und einer unsichtbaren Region in dem zweidimensionalen Bild auf der Grundlage des Grenzbereiches; 40
- einem Dreidimensional-Modell-Schätzschritt zum Schätzen eines dreidimensionalen Modells entsprechend der sichtbaren Region auf der Grundlage von Luminanzinformationen des zweidimensionalen Bildes, durch Ausführen eines geometrischen Umwandlungsprozesses zum Erzeugen eines Voxels entsprechend jedem Pixel in dem zweidimensionalen Bild, und zum Abschätzen eines dreidimensionalen Modells entsprechend der unsichtbaren Region aus Voxeln in der sichtbaren Region, durch Hinzufügen von Voxeln an Positionen, die zum 45
- Grenzbereich symmetrisch sind, und des Weiteren zum Abschätzen eines dreidimensionalen Modells des lebenden Gewebes, als ob das dreidimensionale Modell dem sichtbaren Bereich entspräche und das dreidimensionale Modell dem unsichtbaren Bereich entspräche; einem Formmerkmalswert-Berechnungsschritt zum Berechnen von Formmerkmalswerten jeweiliger Voxel, die zumindest in der sichtbaren Region des dreidimensionalen Modells des lebenden Gewebes enthalten sind; einem Dreidimensional-Form-Extrahierschritt zum Extrahieren einer ersten Voxelgruppe, deren dreidimensionales Modell als eine vorgegebene Form abgeschätzt wurde, in den jeweiligen, in dem dreidimensionalen Modell des lebenden Gewebes enthaltenen Voxeln auf der Grundlage eines Ergebnisses einer Berechnung durch den Formmerkmalswert-Berechnungsschritt; und einem Vorspringform-Ermittlungsschritt zum Ermitteln der ersten Voxelgruppe als eine Voxelgruppe, die eine Vorspringform in dem dreidimensionalen Modell des lebenden Gewebes ausbildet. 50
10. Medizinisches Bildverarbeitungsverfahren nach Anspruch 9, wobei die vorgegebene Form eine konvexe Form ist. 55
11. Medizinisches Bildverarbeitungsverfahren nach Anspruch 9, wobei der Dreidimensional-Form-Extrahierschritt des Weiteren eine zweite Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine konvexe Form abgeschätzt wurde, und eine dritte Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine Dachform abgeschätzt wurde, in Voxelgruppen ermittelt, die in einer gekrümmten Fläche in dem dreidimensionalen Modell des lebenden Gewebes enthalten sind, und, wenn die zweite Voxelgruppe und die dritte Voxelgruppe innerhalb eines vorgegebenen Bereiches liegen, der Dreidimensional-Form-Extrahierschritt die zweite Voxelgruppe und die dritte Voxelgruppe als die erste Voxelgruppe extrahiert. 50
12. Medizinisches Bildverarbeitungsverfahren nach Anspruch 9, wobei der Dreidimensional-Form-Extrahierschritt des Weiteren eine zweite Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine konvexe Form abgeschätzt wurde, und eine dritte Voxelgruppe, die eine Voxelgruppe ist, deren dreidimensionales Modell als eine Dachform abgeschätzt wurde, in Voxelgruppen ermittelt, die in einer gekrümmten Fläche in dem dreidimensionalen Modell des lebenden Gewebes enthalten sind, und, wenn die dritte Voxelgruppe, die sich in der unsichtbaren Region befindet, und die zweite Vo-

xelgruppe, die sich in der sichtbaren Region befindet, innerhalb eines vorgegebenen Bereiches liegen, der Dreidimensional-Form-Extrahierschritt die zweite Voxelgruppe und die dritte Voxelgruppe als die erste Voxelgruppe extrahiert.

13. Medizinisches Bildverarbeitungsverfahren nach Anspruch 11 oder 12, wobei der Dreidimensional-Form-Extrahierschritt des Weiteren auf der Grundlage eines Abstandes zwischen Durchschnittskoor-
dinaten der zweiten Voxelgruppe und Durchschnittskoor-
dinaten der dritten Voxelgruppe bestimmt, ob die dritte Voxelgruppe, die sich in der unsichtbaren Region befindet, und die zweite Voxel-
gruppe, die sich in der sichtbaren Region befindet, innerhalb des vorgegebenen Bereiches liegen oder nicht.
14. Medizinisches Bildverarbeitungsverfahren nach Anspruch 9, wobei der Formmerkmalswert-Berechnungsschritt Formmerkmalswerte bei jeweiligen Voxeln in der sichtbaren Region und bei jeweiligen Voxeln in der unsichtbaren Region berechnet.
15. Medizinisches Bildverarbeitungsverfahren nach Anspruch 9, wobei der Formmerkmalswert-Berechnungsschritt Formmerkmalswerte nur in jeweiligen Voxeln in der sichtbaren Region berechnet.
16. Medizinisches Bildverarbeitungsverfahren nach Anspruch 9, wobei der Formmerkmalswert-Berechnungsschritt auf der Grundlage von Randregion-Voxelinformationen, die Informationen über Voxel sind, die sich in einer Randregion eines Voxels befinden, die Formmerkmalswerte des einen Voxels berechnet und, wenn der Formmerkmalswert-Berechnungsschritt erkannt hat, dass ein Voxel, welches den Grenzbereich umfasst, innerhalb der Randregion liegt, der Formmerkmalswert-Berechnungsschritt Randvoxelinformationen verringert, die zum Berechnen der Formmerkmalswerte des einen Voxels verwendet werden.

Revendications

1. Appareil de traitement d'images médicales comprenant :

une section de détection de région configurée pour détecter, comme partie formant limite, une partie de bord correspondant à une condition prédéterminée parmi toutes les parties de bord contenues dans une image en deux dimensions obtenue en capturant une image d'un tissu vivant dans une cavité de corps, et pour détecter en outre, sur la base de la partie formant limite, une région visible et une région invisible dans

l'image en deux dimensions ;

une section d'estimation de modèle en trois dimensions configurée pour estimer, sur la base d'informations de luminance de l'image en deux dimensions, un modèle en trois dimensions correspondant à la région visible en exécutant un processus de conversion géométrique pour générer un voxel correspondant à chaque pixel dans l'image en deux dimensions, et pour estimer, à partir des voxels contenus dans la région visible, un modèle en trois dimensions correspondant à la région invisible en ajoutant des voxels au niveau des positions symétriques par rapport à la partie formant limite, et pour estimer en outre un modèle en trois dimensions du tissu vivant comme ayant le modèle en trois dimensions correspondant à la région visible et le modèle en trois dimensions correspondant à la région invisible ;

une section de calcul de valeur caractéristique de forme configurée pour calculer des valeurs caractéristiques de forme des voxels respectifs contenus au moins dans la région visible du modèle en trois dimensions du tissu vivant ;

une section d'extraction de forme en trois dimensions configurée pour extraire un premier groupe de voxels dont le modèle en trois dimensions a été estimé comme forme prédéterminée, dans les voxels respectifs contenus dans le modèle en trois dimensions du tissu vivant, sur la base d'un résultat de calcul par la section de calcul de valeur caractéristique de forme ; et
une section de détection de forme saillante configurée pour détecter le premier groupe de voxels en tant que groupe de voxels configurant une forme saillante dans le modèle en trois dimensions du tissu vivant.

2. Appareil de traitement d'images médicales selon la revendication 1, dans lequel la forme prédéterminée est une forme complexe.
3. Appareil de traitement d'images médicales selon la revendication 1, dans lequel la section d'extraction de forme en trois dimensions détecte en outre un deuxième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme convexe et un troisième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme de toit, dans des groupes de voxels contenus dans un plan incurvé dans le modèle en trois dimensions du tissu vivant, et si le deuxième groupe de voxels et le troisième groupe de voxels se situent à l'intérieur d'une plage prédéterminée, la section d'extraction de forme en trois dimensions extrait le deuxième groupe de voxels et le troisième groupe de voxels en tant que premier groupe de voxels.

4. Appareil de traitement d'images médicales selon la revendication 1, dans lequel la section d'extraction de forme en trois dimensions détecte en outre un deuxième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme convexe et un troisième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme de toit, dans des groupes de voxels contenus dans un plan incurvé dans le modèle en trois dimensions du tissu vivant, et si le troisième groupe de voxels se trouvant dans la région invisible et le deuxième groupe de voxels se trouvant dans la région visible se situent à l'intérieur d'une plage prédéterminée, la section d'extraction de forme en trois dimensions extrait le deuxième groupe de voxels et le troisième groupe de voxels en tant que premier groupe de voxels.

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5. Appareil de traitement d'images médicales selon la revendication 3 ou 4, dans lequel la section d'extraction de forme en trois dimensions détermine en outre si oui ou non le troisième groupe de voxels se trouvant dans la région invisible et le deuxième groupe de voxels se trouvant dans la région visible se situent à l'intérieur de la plage prédéterminée, sur la base d'une distance entre les coordonnées moyennes du deuxième groupe de voxels et les coordonnées moyennes du troisième groupe de voxels.

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6. Appareil de traitement d'images médicales selon la revendication 1, dans lequel la section de calcul de valeur caractéristique de forme calcule des valeurs caractéristiques de forme au niveau des voxels respectifs contenus dans la région visible et des voxels respectifs contenus dans la région invisible.

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7. Appareil de traitement d'images médicales selon la revendication 1, dans lequel la section de calcul de valeur caractéristique de forme calcule des valeurs caractéristiques de forme uniquement dans les voxels respectifs contenus dans la région visible.

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8. Appareil de traitement d'images médicales selon la revendication 1, dans lequel sur la base des informations de voxels de région périphérique qui sont des informations sur les voxels se trouvant dans une région périphérique d'un voxel, la section de calcul de valeur caractéristique de forme calcule les valeurs caractéristiques de forme d'un voxel, et si la section de calcul de valeur caractéristique de forme a détecté qu'un voxel contenant une partie formant limite se trouve à l'intérieur de la région périphérique, la section de calcul de valeur caractéristique de forme réduit les informations de voxels périphériques utilisées pour calculer les valeurs caractéristiques de forme du voxel.

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9. Procédé de traitement d'images médicales comprenant :

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une étape de détection de région consistant à détecter, en tant que partie formant limite, une partie de bord correspondant à une condition prédéterminée parmi toutes les parties de bord contenues dans une image en deux dimensions obtenue en capturant une image d'un tissu vivant dans une cavité de corps, et à détecter en outre, sur la base de la partie formant limite, une région visible et une région invisible dans l'image en deux dimensions ;

une étape d'estimation de modèle en trois dimensions consistant à estimer, sur la base des informations de luminance de l'image en deux dimensions, un modèle en trois dimensions correspondant à une région visible en exécutant un processus de conversion géométrique pour générer un voxel correspondant à chaque pixel dans l'image en deux dimensions, et à estimer, à partir des voxels contenus dans la région visible, un modèle en trois dimensions correspondant à la région invisible en ajoutant des voxels au niveau des positions symétriques par rapport à la partie formant limite, et à estimer de plus un modèle en trois dimensions du tissu vivant comme ayant le modèle en trois dimensions correspondant à la région visible et le modèle en trois dimensions correspondant à la région invisible ;

une étape de calcul de valeur caractéristique de forme consistant à calculer des valeurs caractéristiques de forme des voxels respectifs contenus au moins dans la région visible du modèle en trois dimensions du tissu vivant ;

une étape d'extraction de forme en trois dimensions consistant à extraire un premier groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme prédéterminée, dans les voxels respectifs contenus dans le modèle en trois dimensions du tissu vivant, sur la base d'un résultat de calcul par la section de calcul de valeur caractéristique de forme ; et

une étape de détection de forme saillante consistant à détecter le premier groupe de voxels en tant que groupe de voxels configurant une forme saillante dans le modèle en trois dimensions du tissu vivant.
10. Procédé de traitement d'images médicales selon la revendication 9, dans lequel la forme prédéterminée est une forme convexe.

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11. Procédé de traitement d'images médicales selon la revendication 9, dans lequel l'étape d'extraction de forme en trois dimensions détecte en outre un deuxième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été es-

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timé en tant que forme convexe et un troisième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme de toit, dans les groupes de voxels contenus dans un plan incurvé dans le modèle en trois dimensions du tissu vivant, et si le deuxième groupe de voxels et le troisième groupe de voxels se situent à l'intérieur d'une plage prédéterminée, l'étape d'extraction de forme en trois dimensions extrait le deuxième groupe de voxels et le troisième groupe de voxels en tant que premier groupe de voxels.

12. Procédé de traitement d'images médicales selon la revendication 9, dans lequel l'étape d'extraction de forme en trois dimensions détecte en outre un deuxième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme convexe et un troisième groupe de voxels qui est un groupe de voxels dont le modèle en trois dimensions a été estimé en tant que forme de toit, dans les groupes de voxels contenus dans un plan incurvé dans le modèle en trois dimensions du tissu vivant, et si le troisième groupe de voxels se trouvant dans la région invisible et le deuxième groupe de voxels se trouvant dans la région visible se situent à l'intérieur d'une plage prédéterminée, l'étape d'extraction de forme en trois dimensions extrait le deuxième groupe de voxels et le troisième groupe de voxels en tant que premier groupe de voxels.
13. Procédé de traitement d'images médicales selon la revendication 11 ou 12, dans lequel l'étape d'extraction de forme en trois dimensions détermine en outre si oui ou non le troisième groupe de voxels se trouvant dans la région invisible et le deuxième groupe de voxels se trouvant dans la région visible se situent à l'intérieur de la plage prédéterminée, sur la base d'une distance entre les coordonnées moyennes du deuxième groupe de voxels et les coordonnées moyennes du troisième groupe de voxels.
14. Procédé de traitement d'images médicales selon la revendication 9, dans lequel l'étape de calcul de valeur caractéristique de forme calcule des valeurs caractéristiques de forme au niveau des voxels respectifs contenus dans la région visible et des voxels respectifs contenus dans la région invisible.
15. Procédé de traitement d'images médicales selon la revendication 9, dans lequel l'étape de calcul de valeur caractéristique de forme calcule les valeurs caractéristiques de forme seulement dans les voxels respectifs contenus dans la région visible.
16. Procédé de traitement d'images médicales selon la revendication 9, dans lequel, sur la base des informations de voxels de région périphérique qui sont

des informations sur les voxels se trouvant dans une région périphérique d'un voxel, l'étape de calcul de valeur caractéristique de forme calcule les valeurs caractéristiques de forme du voxel, et si l'étape de calcul de valeur caractéristique de forme a détecté qu'un voxel contenant la partie formant limite se trouve à l'intérieur de la région périphérique, l'étape de calcul de valeur caractéristique de forme réduit les informations de voxels périphériques utilisées pour calculer les valeurs caractéristiques de forme du voxel.

FIG.1

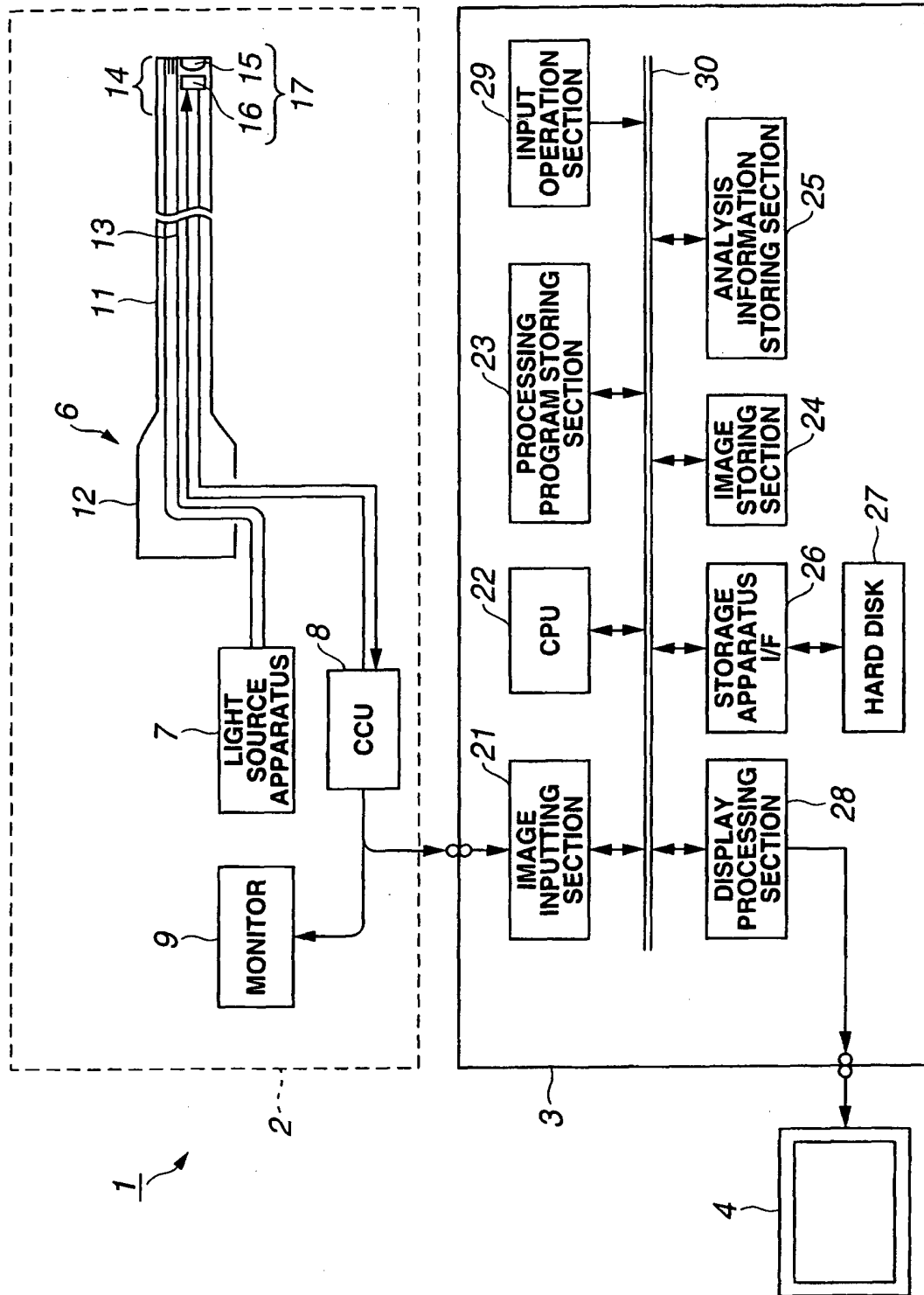


FIG.2

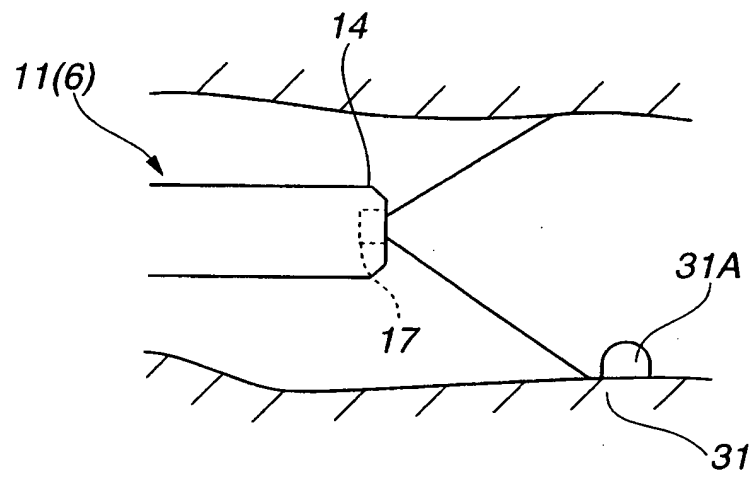


FIG.3

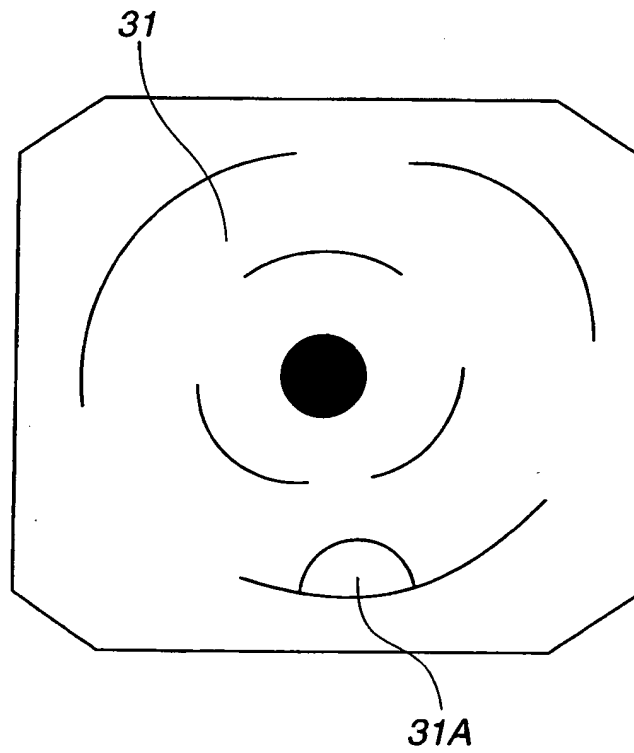


FIG.4

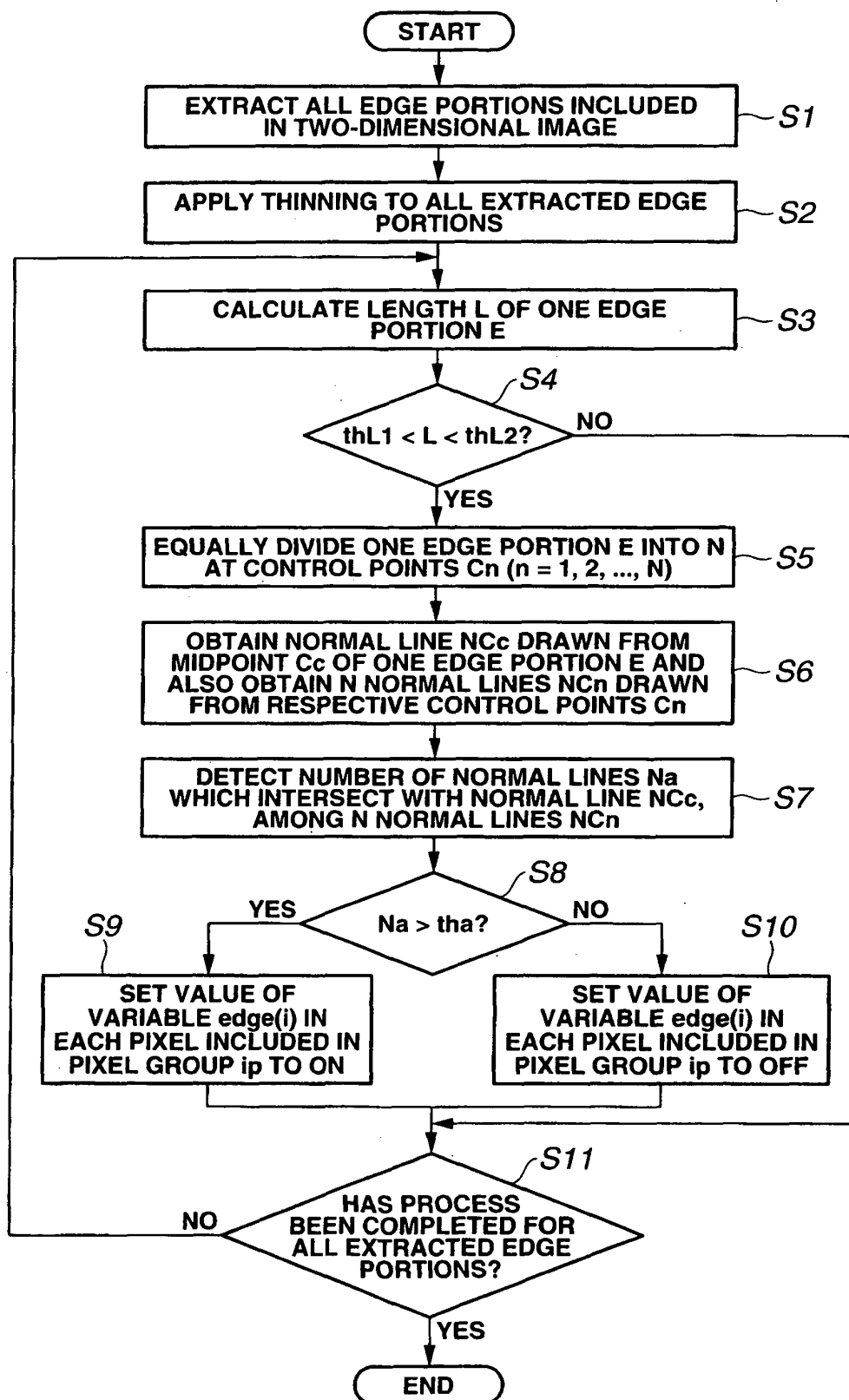


FIG.5

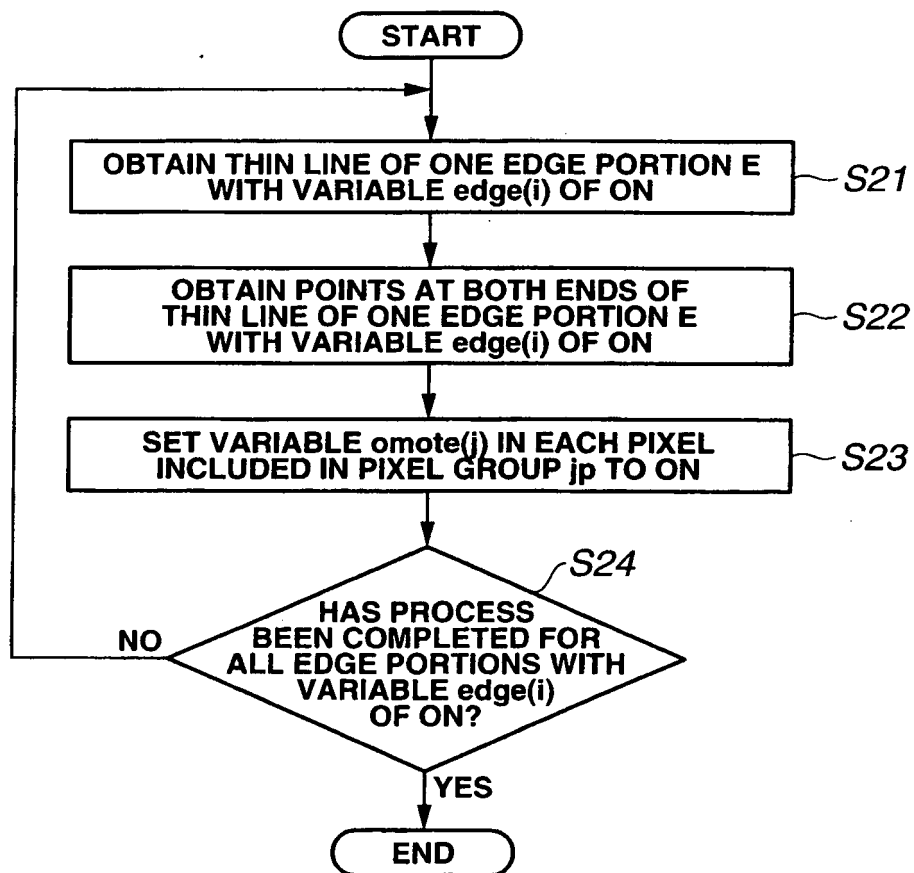


FIG.6

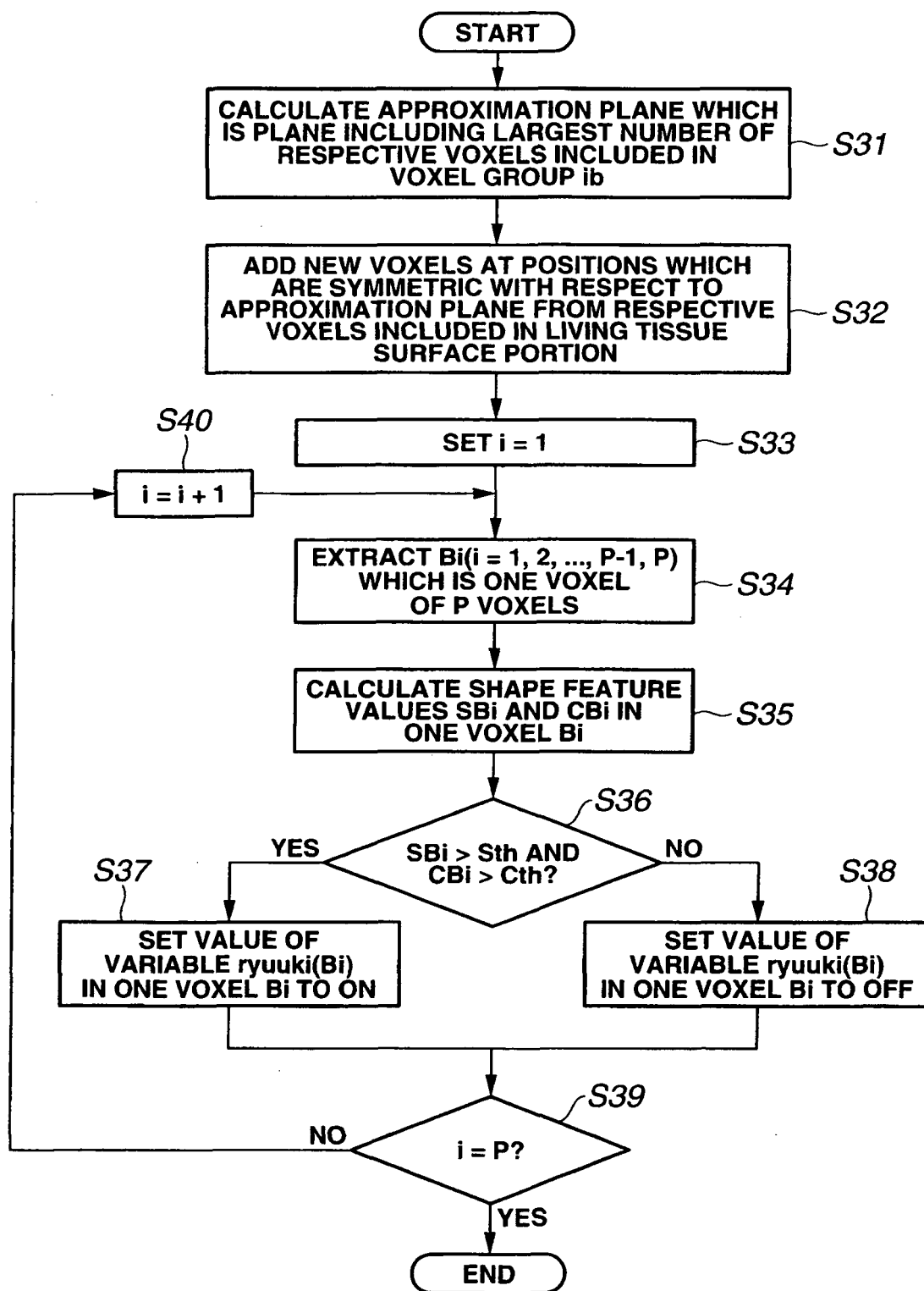


FIG.7

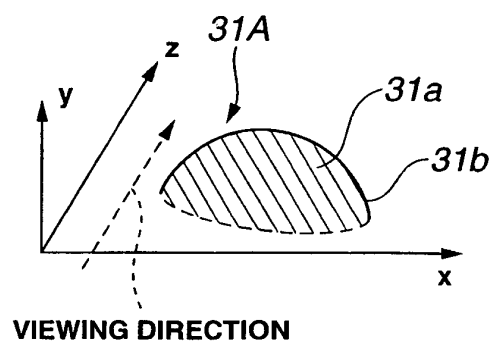


FIG.8

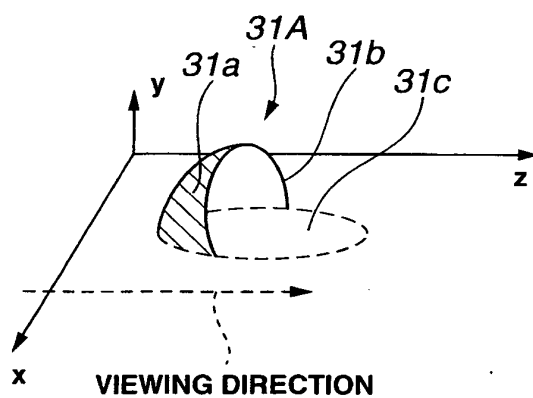


FIG.9

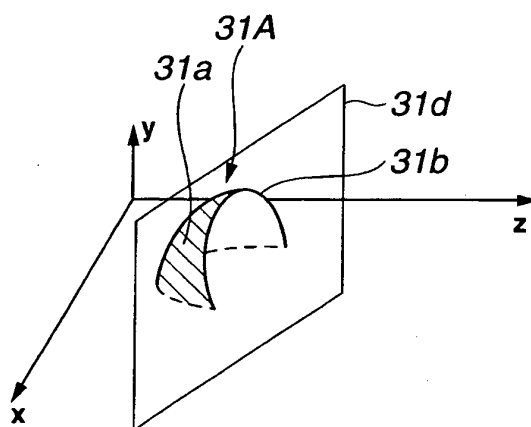


FIG.10

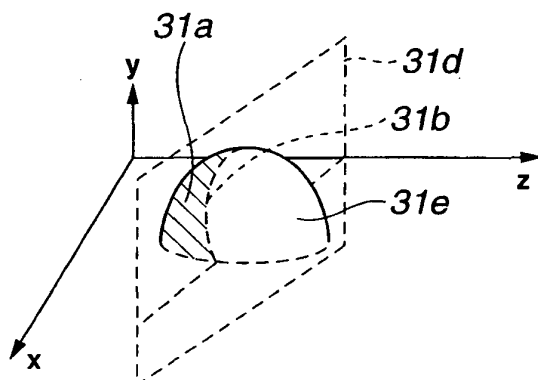


FIG.11

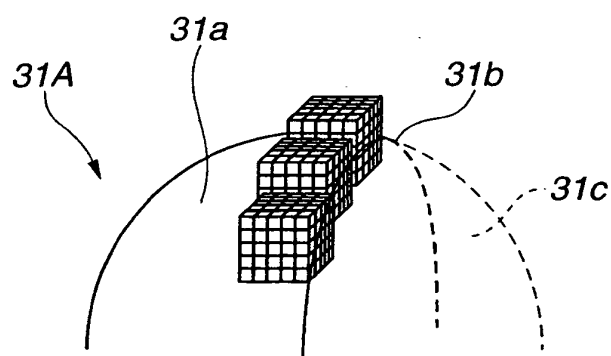


FIG.12

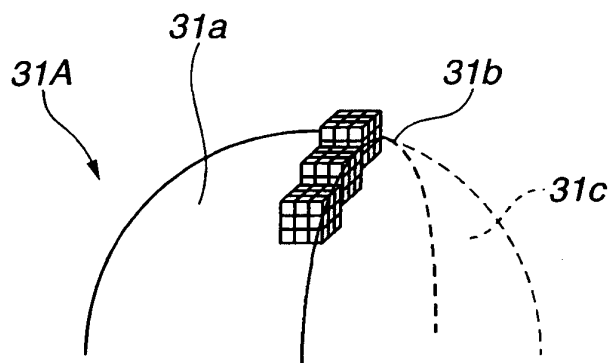


FIG.13

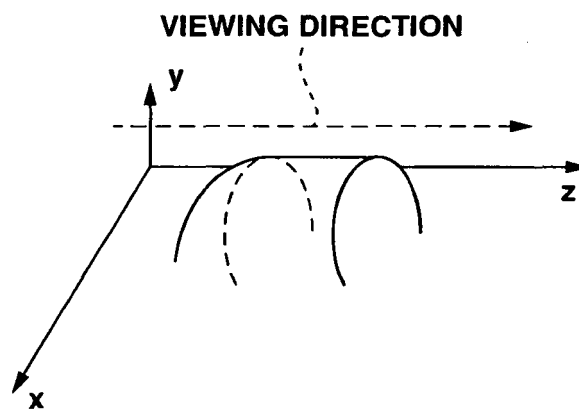


FIG.14

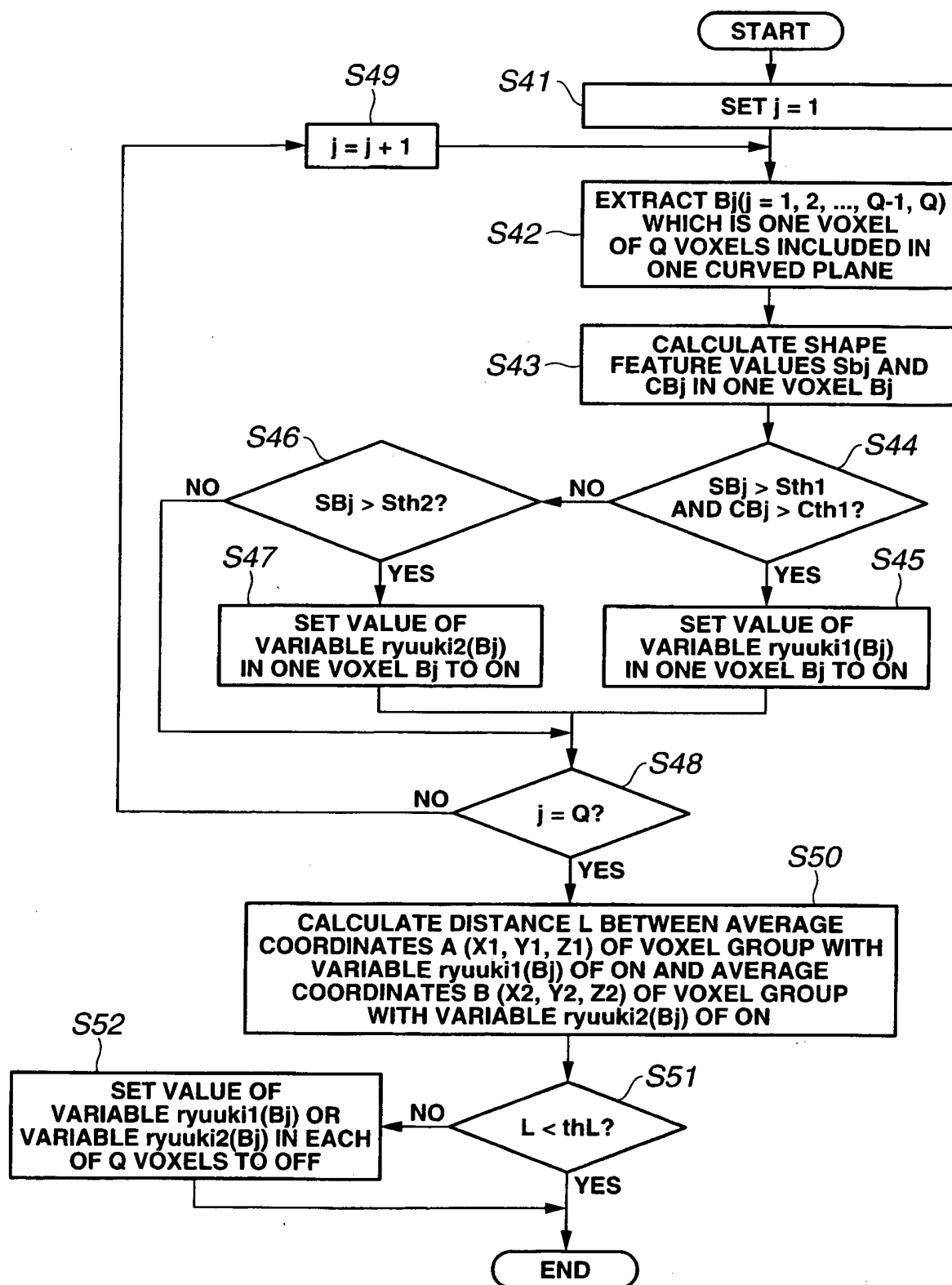
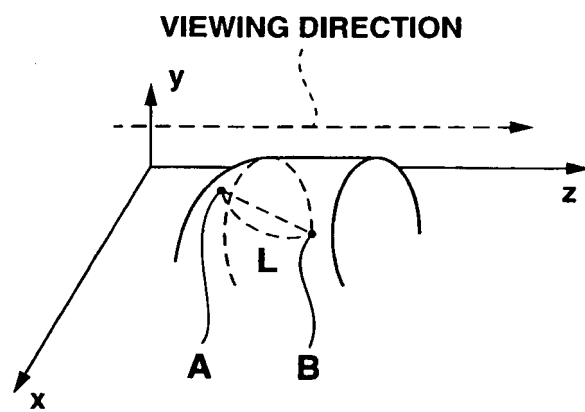


FIG.15



REFERENCES CITED IN THE DESCRIPTION

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